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INFORMATION CIRCULAR

# EXPLOSIONS IN NEW MEXICO COAL MINES, 1895 TO 1932

BY

G. M. KINTZ

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# EXPLOSIONS IN NEW MEXICO COAL MINES 1895 TO 1932 1/

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## INTRODUCTION

From 1895 to 1932, inclusive, 1,016 3/ men were killed in and about New Mexico coal mines. Of these, 473 (approximately 47 percent) were killed in the 17 explosions listed in this paper. The second largest explosion of record in the United States, in so far as fatalities are concerned, occurred in New Mexico.

The data in this circular were taken from publications of the United States Bureau of Mines and published annual reports of the State inspector of coal mines of New Mexico. The tables included are complete only with regard to major disasters. The Bureau of Mines considers as a major disaster one in which 5 or more men are killed. A few minor disasters are included, however.

This is one of a series of papers published by the Bureau of Mines to give by States the data available regarding coal-mine explosions in the hope that the information may assist in eliminating similar conditions of potential danger now existing in many coal mines of the United States.

## EXPLOSIONS

Tables 1 and 2 give available data on the cause, number of men killed and injured, and possible means of prevention at the time of 17 explosions in New Mexico from 1895 to 1932, inclusive.

Nature of explosions.- Seven of the explosions listed occurred before 1913. The nature of the explosions with reference to gas and coal dust is stated in table 3.

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1/ The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6760."

2/ Associate mining engineer, U. S. Bureau of Mines Safety Station, Denver, Colo.

3/ This figure is compiled from U. S. Bureau of Mines Bulletins 115, 275, and 355 and C.M.F. 18.



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In the 4 gas explosions listed 15 men were killed and 9 injured; in the 7 dust explosions 400 men were killed and only 6 injured; in the 4 gas and dust explosions 34 men were killed and 9 injured.

These figures illustrate that usually where coal dust is a factor in an explosion the destruction of life and property is much greater than when gas alone is the exploding medium. They show the necessity of thorough rock-dusting, with sprinkling of working places and of haulage trips where possible, to prevent participation of coal dust in explosions in bituminous and lignitic coal mines. A gas and dust explosion is likely to be more disastrous than either a gas or dust explosion alone; in fact, nearly all widespread coal-mine explosions have involved both gas and dust. Some coal mined in New Mexico has dust which rates among the most inflammable of the coal dusts of the United States. In addition many, if not most, of these mines also give off explosive gas of a decidedly dangerous combination, which is reflected in the very bad record of New Mexico as to fatalities from coal-mine explosions. The need for strict enforcement of the rock-dusting clause in the mining code recently enacted by the New Mexico legislature is also indicated by these facts and figures.

Explosives used.- The use of black blasting powder or dynamite or the improper use of permissible explosives caused 7 of the explosions resulting in the death of 285 men. The poor placement of drill holes, excessively heavy charging of explosive, insufficient or improper tamping of holes, and failure to undercut the coal were some of the reasons for blown-out shots.

The explosives now designated as "permissible" were first used in 1907. Since that time explosives manufacturers have continually improved them, and it is now possible to obtain permissible explosives that, with intelligent use, will give practically as effective blasting results as black blasting powder. Explosives engineers have proved that the production of lump coal does not depend wholly upon the speed of detonation of an explosive and that strength and density, as well as proper placing of holes, are also important factors. The best method of determining the proper permissible explosive to use in any coal mine is to consult the explosives manufacturers, who have engineers well qualified to recommend the proper grade; the tests should be conducted under the constant watchful supervision of some person or persons known to be sympathetic with trying to secure a safe, effective type of explosive.

Under the new New Mexico coal-mining code only permissible explosives fired electrically are permitted, except where shooting is done from the surface and in certain special rockwork.

If permissible explosives are not used according to the methods prescribed by the United States Bureau of Mines and the manufacturers they may ignite an explosive mixture of gas or a coal-dust cloud. Even though the explosive is properly manufactured and approved by the Bureau of Mines it is not permissible used in any of the following ways:

1. If stored under improper conditions until it changes in character.
2. If used frozen or partly frozen.
3. If more than 1½ pounds are used per shot.



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Table 1. - Explosions in New Mexico coal mines, 1895 - 1932

| Case | Date | County | Type of opening | Tons per year | Number employed | Number in mine | Extent of explosion | Cause of the presence of an explosive atmosphere | Probable source of ignition | Possible means of prevention at time | Gas or dust explosion | Number killed | Number injured | Number escaped uninjured |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2/27/1895 | Santa Fe. | Slope. | - - | - - | - - | Entire mine. | - - | - - | - - | - - | 24 | - | - |
| 2 | 4/21/1899 | do. | do. | - - | - - | - - | do. | - - | - - | - - | - - | 5 | - | - |
| 3 | 3/29/1901 | McKinley. | do. | 50,000 | 125 | - - | do. | Dust raised by shots. | Blown-out shot of black blasting powder. | State mine inspector recommended mine be kept clean and drill holes placed better. | Dust. | 3 | - | - |
| 4 | 9/5/1903 | Colfax. | Drift. | 443,398 | 307 | 0 | Local. | Gases distilled from burning coal. | Mine fire. | - - | Gas. | 0 | - | - |
| 5 | 10/5/1906 | do. | do. | 107,012 | 78 | Unknown. | - - | - - | Said to be an open light. | - - | Gas and dust. | 10 | - | - |
| 6 | 12/31/1907 | Socorro. | Slope. | 63,866 | 35 | do. | Entire mine. | Blown-out shots raised dust cloud. | Blown-out shot of frozen 40 percent dynamite. | - - | do. | 11 | 3 | 2 |
| 7 | 3/17/1910 | McKinley. | do. | 272,845 | 210 | do. | Local | Dust raised by shots. | Blown-out shot of black blasting powder. | State mine inspector recommended mine be kept clean and drill holes placed better. | do. | 0 | 2 | - |
| 8 | 10/22/1913 | Colfax. | Drift. | - - | 312 | do. | Entire mine. | Dust raised by shots fired in violation of company rules. | Blown-out shot. | Sprinkling, rock-dusting, use of permissible explosive for all blasting. | do. | 263 | - | 24 |
| 9 | 10/23/1918 | McKinley. | - - | - - | - - | 2 | do. | Dust raised by shots. | Blown-out shot and keg of black blasting powder. | Sprinkling, rock-dusting, use of permissible explosive, better tamping, location of holes. | Gas and dust. | 2 | 0 | - |
| 10 | 4/14/1920 | Colfax. | Drift. | - - | - - | - - | do. | do. | Blown-out shot. | Sprinkling, thorough rock-dusting, use of permissible explosive according to Bureau of Mines recommendations. | Dust. | 5 | 0 | - |
| 11 | 5/5/1921 | Santa Fe. | Slope. | 36,327 | - - | - - | Local. | - - | - - | Improved ventilation. | Gas. | 1 | - | - |
| 12 | 11/25/1922 | do. | do. | 74,352 | 101 | Unknown. | do. | Sudden outflow of gas. | Electric arc from non-permissible electric motor driving a conveyor. | Better ventilation of working places. | do. | 12 | 9 | - |
| 13 | 2/8/1923 | Colfax. | Drift. | - - | 172 | 122 | Entire mine. | Wrecked trip. | Electric arc from trolley. | Sprinkling trips. | Dust. | 120 | 0 | 2 |
| 14 | 11/15/1930 | Santa Fe. | Slope. | 50,500 | 111 | 111 | Local. | Driving drift too far ahead of air. | Electric arc from mining machine. | Use of line brattice to face and permissible mining machine. | Gas. | 2 | 0 | - |
| 15 | 11/17/1930 | do. | do. | 3,110 | 15 | 2 | Entire mine. | Dust raised by shots. | Blown-out shot of black blasting powder. | Permissible explosives, rock-dusting and sprinkling dust. | Dust. | 1 | 1 | - |
| 16 | 12/6/1930 | do. | do. | 46,697 | 81 | 81 | Local. | Lack of line brattice and shutting off of blower fan. | Arc from dry electric oil switch. | Use of line brattice in place of blower fan. | Gas and dust. | 5 | 7 | - |
| 17 | 12/7/1932 | do. | do. | 38,683 | 55 | 55 | do. | Door left open short-circuited air. | Electric arc from 60-volt bell line. | Use of overcast in place of doors. | do. | 14 | 2 | 39 |

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Table 2. - Number of explosions and men killed and injured in New Mexico coal mines by years

| Year | Number of explosions | Number killed | Number injured | Year | Number of explosions | Number killed | Number injured |
|---|---|---|---|---|---|---|---|
| 1895 | 1 | 24 | - | 1918 | 1 | 2 | - |
| 1899 | 1 | 5 | - | 1920 | 1 | 5 | - |
| 1901 | 1 | 3 | - | 1921 | 1 | 1 | - |
| 1903 | 1 | 0 | - | 1922 | 1 | 12 | 9 |
| 1906 | 1 | 10 | - | 1923 | 1 | 120 | - |
| 1907 | 1 | 11 | 3 | 1930 | 3 | 8 | 8 |
| 1910 | 1 | 0 | 2 | 1932 | 1 | 14 | 2 |
| 1913 | 1 | 263 | - | Total | 17 | 478 | 24 |

Table 3. - Nature of explosions with reference to gas or coal dust

| Nature of explosion | Number of explosions | Number killed | Number injured |
|---|---|---|---|
| Unknown | 2 | 29 | 0 |
| Gas | 4 | 15 | 9 |
| Dust | 7 | 400 | 6 |
| Gas and dust | 4 | 34 | 9 |
| Total | 17 | 478 | 24 |

Table 4. - Sources of ignition

| Cause | Number of explosions | Number killed | Number injured |
|---|---|---|---|
| Blown-out shot | 7 | 285 | 6 |
| Open light | 1 | 10 | |
| Electric | 5 | 153 | 18 |
| Mine fire | 1 | | |
| Unknown | 3 | 30 | |
| Total | 17 | 478 | 24 |



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4. If the diameter of the cartridge is less than that designated in the column "smallest permissible diameter".

5. If fired with an electric detonator of less efficiency than that prescribed or if fired by means of a nonpermissible-type blasting unit.

6. If fired with fuse.

7. If fired without stemming.

8. If fired with combustible stemming.

9. If fired in the presence of a dangerous percentage of fire damp.

10. If the shot is a depending shot, is bored into the solid, or has a burden so heavy that the shot obviously is liable to blow out.

Electricity.- Electricity caused 6 explosions resulting in the death of 153 men. With the increased use of electricity in the coal mines of the United States there has been an alarming increase in the number of gas ignitions and mine explosions from electric arcs.

This condition will continue until the use of nonpermissible electrical equipment is prohibited in any part of the mine not properly rock-dusted and ventilated by a positive current of air which cannot be short-circuited by human error, such as leaving a door or curtain open or improperly installing line brattice.

Where permissible electrical equipment is used and maintained in permissible condition it greatly reduces the hazard of gas ignition in mines that may become gassy.

The Mine Safety Board of the United States Bureau of Mines[4/] makes the following recommendation regarding electricity in coal mines:

> The United States Bureau of Mines recommends that when electricity is used in coal mines rated as gassy, or whenever in any mine the atmosphere may become gassy:
>
> 1. Electrical equipment shall be permissible.
>
> 2. Nonpermissible electrical equipment shall be used only in pure intake air.
>
> 3. Electrical power shall be cut off whenever the air in the workings is in a dangerous condition, due to inflammable gas.

4/ Mine Safety Board, Decision 13: Inf. Circ. 6732, Bureau of Mines, 1933, 43 pp.



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Operators and mine electricians will find much instructive information regarding electricity in mines in United States Bureau of Mines Technical Paper 402, Safety Rules for Installing and Using Electrical Equipment in Coal Mines.

Mine fires.- The report of the Territorial United States mine inspector gives the cause of the explosion listed as case 4 as fire igniting gases distilled from the heated coal; during the fighting of mine fires in soft-coal mines there is always great hazard of a gas ignition, and men fighting such fires should fully realize this hazard, taking all possible precautions to protect themselves.

Open lights.- Case 5 is the only one in which it is said that an explosion in a New Mexico coal mine was caused by an open light. There have probably been others the records of which are not available to the writer; case 8 is ascribed by some mining men to open-light ignition, although the generally accepted cause is a blown-out shot.

The new (1933) State mining code (section 136) forbids the use of open lights in gassy coal mines or in any mine employing more than 10 men underground. Only permissible safety lamps, either flame or electric, approved by the United States Bureau of Mines shall be used as portable lights in the larger coal mines of New Mexico.

Unknown.- Two explosions are classified as of unknown origin, because the records available are incomplete.

## MEANS OF PREVENTING THE EXPLOSION AT THE TIME

Better ventilation.- Better ventilation of working places by use of overcasts in place of doors, line brattice in place of blower fans, or line brattice from the last open crosscut to the face, with a sufficient quantity of air available, would have prevented the accumulation of gas in all the cases listed wherein explosive gas was a factor.

If the recommendations made in the following decision No. 9[5] of the Mine Safety Board are strictly adhered to there should be few if any gas explosions:

> Bureau of Mines, Department of Commerce, recommends, in coal-mine ventilation practice, the following specifications as to unit quantity and quality of air:
>
> 1. The quantity in cubic feet of pure intake air flowing per minute in any ventilating split shall be at least equal to 100 times the number of men in that split.

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5/ See footnote 4.



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2. The quantity of air entering each unsealed place shall be at least 200 cubic feet per minute and as much more as may be necessary to properly dilute and carry away inflammable or harmful gases which may be present.

3. The air shall be made to circulate continuously to the face in every unsealed place into which an appreciable amount of methane enters.

4. The air in any unsealed place shall be considered unfit for men if it shall be found to contain less than 19 percent oxygen (dry basis), more than 1 percent carbon dioxide, or a harmful amount of poisonous gas.

5. If the air in any unsealed place, when sampled or tested in any part of that place not nearer than 4 feet from the face and 10 inches from the roof, shall be found to contain--

(a) More than 1½ percent of inflammable gas, the place shall be considered to be in hazardous condition and require improved ventilation; and

(b) If more than 2½ percent of inflammable gas is found, the place shall be considered dangerous and only men who have been officially designated to improve the ventilation and are properly protected shall remain in or enter said place.

6. If the air in the split which ventilates any group of workings contains more than 1½ percent of inflammable gas, these workingsshall be considered to be in a dangerous condition and only men who have been officially designated to improve the ventilation and are properly protected shall remain in or enter said workings.

Rock-dusting.- Some New Mexico coal mines were among the first in the West to use rock-dust to prevent coal-dust from being a factor in explosions, and several are now among the best rock-dusted mines in the United States.

In at least two explosions in Santa Fe County the records indicate that the explosions were localized by rock-dust. The localization of these explosions is thought to have resulted in the saving of nearly a hundred lives; this fact was strongly stressed by the newspapers and the State coal-mine inspector's annual reports. Even in view of these published statements there were, until the passage of the recent mining code, numerous coal mines in the State that did not use rock-dust in any form.

The State coal mining code of 1933 (article 23) requires thorough rock-dusting of all mines, except those producing pure anthracite, unless all coal dust on floor, ribs, and roof and timber is muddy at all times. This code also specifies the type of dust that may be used, the amount, the



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method and time of sampling, and the method of recording the results of analyses of dust samples. Rock-dust barriers are also required, and the amount of dust in each barrier is specified.

Records indicate that as far back as 1894 sprinkling was practiced in Colorado to prevent participation of coal dust in explosions. At present one mine in New Mexico has water piped to every working face; the company operating this mine strictly enforces a rule requiring every miner to keep his place thoroughly wetted down. Several mines in the State sprinkle trips at sectional and main partings. The Bureau of Mines makes the following recommendations6/ regarding sprinkling in coal mines:

In the interest of safety in coal mining, the United States Bureau of Mines to lessen the coal-dust hazard recommends that:

1. Machine coal cuttings be wet as the cutting is being done.

2. The coal face, and the working place 40 feet therefrom, shall be kept free of coal-dust by the use of water.

3. The top of loaded cars in the working place shall be wet.

Coal-dust is inevitably produced in the cutting, blasting, and loading of coal. The above recommendations are aimed at wetting, so far as practicable, the dust at the point of its formation in the working places and thus prevent it from rising, as a dry dust will do, into the air and being carried by the air current into adjacent places.

Recommendations 2 and 3, advocating wetting the coal face and tops of loaded cars, can best be effected by having water lines extending to each face and watering by hose, each face region being kept supplied with suitable hose.

These recommendations do not apply to anthracite mines the dust of which will not propagate an explosion.

Table 5. - Causes of gas accumulations or coal-dust clouds

| Cause | No. of explosions | No. killed | No. injured |
|---|---|---|---|
| 1. Air short-circuited through doors or curtains | 1 | 14 | 2 |
| 2. Use of mechanical blower in place of line brattice | 1 | 5 | 7 |
| 3. Driving drift too far ahead of last open crosscut | 1 | 2 | - |
| 4. Sudden outflow of gas | 1 | 12 | 9 |
| 5. Coal-dust cloud raised by shots | 7 | 285 | 6 |
| 6. Coal-dust cloud raised by wrecked trip | 1 | 120 | - |
| 7. Gas distilled from coal by mine fire | 1 | - | - |
| 8. Unknown | 4 | 40 | - |
| Total | 17 | 478 | 24 |

6/ See footnote 4.



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Air short-circuited through doors.- It is almost impossible to operate a coal mine without some doors, but they should be in pairs or supplemented with curtains; they should be self-closing, and the use of any device to hold them open should be forbidden. In certain New Mexico mines doors can very readily be replaced with overcasts; changes in mining methods and additional air may be required, but the gain in safety will more than justify them.

Use of mechanical blowers in place of line brattice.- Because of the number of explosions that have been caused directly or indirectly by mechanical blowers in coal mines and the other hazards inherent in the use of this equipment the United Stated Bureau of Mines makes the following recommendation7/ regarding blowers in coal mines:

> In the interest of safety, the Bureau of Mines, Department of Commerce, recommends that auxiliary fans or blowers should not be used in coal mines as a substitute for methods of regular and continuous coursing of the air to every face of the mine.

Driving entries too far ahead of the last open crosscut.- The present New Mexico coal-mining law (section 140) provides that

> In gassy mines, entry and room faces shall be ventilated by a current of moving air directly by a line brattice if necessary so as to keep such faces free at all times from gas as determined by a flame safety lamp. Crosscuts in all coal mines shall be driven not more than one hundred feet apart and such lesser distance apart as is necessary to comply with this provision or as ordered by the state mine inspector. In nongassy mines crosscuts shall not be more than one hundred feet apart unless greater distance is authorized by the state mine inspector. No entry or room shall be abandoned until a crosscut has been made at the face.

If this section is strictly followed the probability of an accumulation of explosive gas at working places will be reduced to a minimum.

Sudden outflow of gas.- This hazard can ordinarily be handled by use of permissible equipment, by adequate sealing of abandoned workings, and by proper ventilation. The alertness and knowledge of the mine officials are determining factors in avoiding hazards of this nature.

Coal-dust cloud raised by shots.- Improper location of drill holes, the use of an insufficient number of holes, shooting off the solid, firing of dependent shots, use of combustible or too little or no stemming, and loading holes too heavily cause blown-out shots. These can be eliminated by proper supervision and by education of miners and shot-firers in safe methods. Also, if the shots are loaded and fired when the working shift is out of the mine the likelihood of wholesale fatalities from explosions caused by blown-out shots or from other causes in connection with the use or abuse of explosives in coal mines will be eliminated.

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7/ See footnote 4.



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One mine in New Mexico fires all shots from the outside with every man out of the mine; the explosives are taken into the mine by the shot firers after the shift is out of the mine, and they load and tamp all holes. The next best method is to have a shot firer load, tamp, and fire all the holes with all others out of the mine. A good shot firer who is kept under adequate supervision will not shoot an improperly drilled hole, a place that is not properly undercut, or a place in which the "bug dust" is not removed from the cut; neither will he overload a hole or tamp it with stemming containing coal dust.

The Bureau of Mines recommends that for blasting in coal mines permissible explosive, fired electrically, be exclusively used; and that, as an aid to blasting, all coal which it is feasible to cut should be cut or sheared. (U. S. Bureau of Mines Safety Board decision 2.)9/

Rock-dusting of all places to within a short distance of the working face and thorough wetting of the places before shooting will lessen the likelihood of occurrence of an explosive coal-dust cloud.

Coal-dust clouds raised by wrecked trip.- Properly maintained and inspected haulage equipment and haulageways will aid in preventing wrecks. Sprinkling of trips, thorough rock-dusting of haulageways, and keeping haulageways clean will prevent dust clouds from being raised by a wreck, or if a dust cloud should be ignited the resulting explosion will be localized.

Gas distilled from heated coal at time of a mine fire.- This phenomenon is illustrated by explosions that often occur in coal stoves. In mines, explosions from mine fires are often very violent due to the large amount of inflammable gas and coal-dust present.

A mining system should be so designed that fires can be readily sealed without danger to the operation of the rest of the mine.

## EXPLOSIBILITY OF NEW MEXICO COAL DUST

United States Bureau of Mines tests show that semianthracite, bituminous, and subbituminous coal dust is explosive under certain conditions. Anthracite dust is not thought to be explosive under ordinary conditions.

The presence of even a small quantity of inflammable gas in the mine air increases the explosibility of the dust; an additional quantity of rock-dust must, therefore, be added to neutralize the effect of the gas present, but of course rock-dust will not prevent an explosion when gas is present in explosive proportions (roughly 5 to 15 percent).

9/ See footnote 4.



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## COAL-MINING CODE OF NEW MEXICO

In 1933 through the joint efforts of various mine operators, the Governor, and the State coal-mine inspector, a new code of mining laws was drawn up with specific requirements as to ventilation, rock-dusting, and other explosion-prevention measures. Several operators had these measures in effect long before the passage of the law.

## CONCLUSIONS

New Mexico has had a particularly bad mine-explosion record in the past due to the fact that there have been two very destructive explosions with great lossof life and 15 others with considerable loss of life. These disastrous explosions have occurred in a State employing relatively few men in the coal-mining industry compared with other larger coal-producing States. The explosion-prevention measures introduced in the last decade by several operators have virtually eliminated the danger of a general coal-dust explosion in their mines; if other operators carry out similar measures as provided in the new State law, New Mexico should be able not only to eliminate disastrous coal-mine explosions completely but also to reduce the coal-mine accident rate so that it will compare favorably with rates for other States.



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